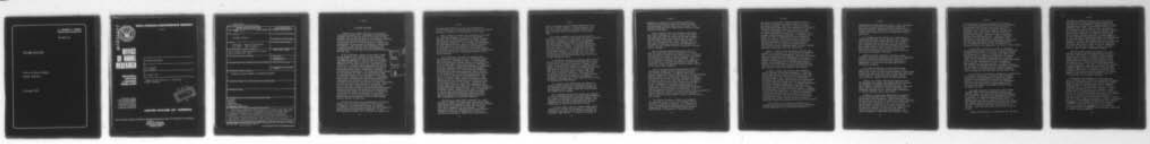
AD-A035 077 OFFICE OF NAVAL RESEARCH LONDON (ENGLAND) F/G 5/10
VIGILANCE REVISITED.(U)
OCT 76 R R MACKIE, J A NAGAY
UNCLASSIFIED ONRL-C-35-76 NL

1 OF 1
AD-A
035 077



END
DATE
FILMED
3-8-77
NTIS

VIGILANCE REVISITED

OFFICE OF NAVAL RESEARCH
LONDON (ENGLAND)

6 OCTOBER 1976

ONR LONDON CONFERENCE REPORT

C-35-76

OFFICE OF NAVAL RESEARCH

BRANCH OFFICE LONDON ENGLAND

VIGILANCE REVISITED

R.R. Mackie*
J.A. Nagay**

6 October 1976

*(Human Factors Research Inc., Goleta,CA)
**(ONR, Arlington)

UNITED STATES OF AMERICA

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE *(When Data Entered)*

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER ONRL-C-35-76	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE *(and Subtitle)* VIGILANCE REVISITED		5. TYPE OF REPORT & PERIOD COVERED
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) R.R. Mackie (Human Factors Research) J.A. Nagay (ONR, Arlington)		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Office of Naval Research Branch Office London Box 39, FPO New York 09510		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS		12. REPORT DATE 6 October 1976
		13. NUMBER OF PAGES 8
14. MONITORING AGENCY NAME & ADDRESS*(if different from Controlling Office)*		15. SECURITY CLASS. *(of this report)*
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT *(of this Report)*

APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED

17. DISTRIBUTION STATEMENT *(of the abstract entered in Block 20, if different from Report)*

18. SUPPLEMENTARY NOTES

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

vigilance
fatigue
monitoring
target detection
performance measurement

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

This report summarizes a meeting held in St. Vincent, Italy (Aug. 1976) in which 65 specialists from 14 countries discussed and presented papers on "Relationships among Theory, Physiological Correlates, and Operational Performance." Problem areas considered included vigilance decrement encountered during the operation of ground and airborne vehicles, sonar and radar systems, industrial equipment, and a variety of other situations. Comparisons were drawn between the findings of laboratory and field experiments particularly as the emphasis has shifted during the past few years to field studies.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE
S/N 0102-014-6601

SECURITY CLASSIFICATION OF THIS PAGE *(When Data Entered)*

VIGILANCE REVISITED

A Symposium on Vigilance was held in Italy during the period 3-6 August 1976. Sponsored by the NATO Special Programme Panel on Human Factors and the Office of Naval Research, the meetings took place in the excellent conference facilities of the Grand Hotel Billea in St. Vincent, a small resort town in the Aosta Valley of northern Italy. Approximately 65 persons were in attendance, representing 14 countries. Ten countries were represented in the 37 papers presented over the 4 days of the Symposium. Proceedings will be published as a hard-backed book within the next year.

In his introductory remarks, Robert Mackie (Human Factors Research, Inc., Goleta, CA), the Director of the Symposium, recalled the issues raised in the first international symposium on vigilance which was conducted under HFR auspices some 15 years ago and outlined the differences in the objectives of that symposium and the current one. In general, these differences are implied in the full title of the 1976 Symposium, "Vigilance II: Relationships among Theory, Physiological Correlates, and Operational Performance." In the ensuing years between the two meetings, the study of the operational problem of sustained attention for low probability events that characterizes vigilance tasks has moved to a considerable extent from the laboratory to field settings more nearly approximating the real-world tasks of the air traffic controller, the long-haul truck driver, the radar watchstander, or other jobs where alertness must be maintained. This shift in the locus of research was to be emphasized. Recent significant advances in identifying the physiological correlates of vigilance performance and the implications of physiological models for the resolution of theoretical issues were also among the objectives of the meeting. In addition, it was anticipated that the Symposium would address practical methods for coping with the problems posed by failures of attention.

Further scene-setting was accomplished in the keynote address of Harry Jerison (University of California at Los Angeles). He distinguished between the concepts of sustained versus selective attention and their underlying physiological and psychological mechanisms. He felt that physiological models were in general more appropriate

for sustained attention and that, with the exception of the contributions of signal detection theory, psychological analyses of vigilance are dissatisfying at this time.

Next, a group of 15 papers was presented which focused on e vigilance decrement in a variety of operational settings: motor vehicle operation, the control of trains and aircraft, the monitoring of sonar and radar systems, and industrial inspection. Since a number of investigators had questioned whether the classical vigilance decrement as often observed in the laboratory also occurred to a significant or practical extent in real-world settings, these papers were of particular interest in their implications for the generalizability of laboratory findings to real-world operations.

J.B.J. Riemersma (Institute for Perception TNO, The Netherlands) presented a paper on automobile driving during night and early-morning hours. He hypothesized that declining diurnal rhythm, monotony, and accumulating lack of sleep combine during these hours to contribute to driver "fatigue." Significant decrements of performance on several driving performance measures and secondary tasks were described. E.J. Caille (Centre d'Etudes et de Recherches de Psycologie Appliquée, France) reported on the deterioration of performance during night driving as a function of the driver's carboxyhemoglobin level. James. F. O'Hanlon (Human Factors Research, Inc., USA) contrasted central nervous system and autonomic changes between drivers who performed well and relatively poorly for prolonged periods on the highway. Differences were noted in mean heart rate, heart rate variability, and relative power within the alpha, beta, and delta electro-encephalogram (EEG) frequency bands. H.O. Lisper (University of Uppsala, Sweden) reported on the effects of listening to the car radio during monotonous vehicle operation, and noted substantial differences between the radio's effects on experienced and inexperienced drivers and their extrovertive or introvertive tendencies.

William Harris (Human Factors Research, Inc., USA) reported an analysis of accident data involving long-haul truck drivers which showed that about twice as many accidents occur during the second half of trips than during the first half, irrespective of trip duration. A notable time-of-day effect was identified among drivers who were judged by the accident investigators to be dozing at the time of the accident. About twice as many of these

types of accidents occurred between midnight and 8 a.m. than in the other 16 hours of the day combined. Data were also presented showing a circadian depression of heart rate that closely corresponded to the accident data.

These data appeared to support the work reported by Karl E. Klein (Institut für Flugmedizin, FRG) on circadian performance rhythms in air operations. He presented data from 7 experimental studies in which behavioral and physiological variables were evaluated before and after transmeridian flights. The results confirmed the idea that level of alertness is associated with those biological properties of the organism that are subject to circadian variation. It was shown that this rhythm persists after transmeridian flights and is de- and re-synchronized with the environmental time cues similar to other biological cycles.

H. Fruhstorfer (University of Marburg, FRG) presented data on the use of a "Vigilance Monitoring Device" used to monitor the vigilance of operators of German railroad trains. He presented preliminary data supporting the hypothesis that the train drivers can perform the secondary task posed by this device very well at the same time that there is neurophysiological evidence (EEG, EOG) of a gradual decline in alertness. This supported a finding later reported by Mackie that automobile drivers on extended trips actually showed an improvement in performing a secondary task at the same time their driving was progressively deteriorating.

On a related issue, Robert Dewar (University of Calgary, Canada) reported a study showing that the use of vigilance "loading tasks" in performing research on the perceptability of traffic signs may actually reduce the validity of the findings.

W.P. Colquhoun (University of Sussex, UK) reported a series of experiments which required binaural monitoring of a number of simultaneous active sonar outputs. The detection rate was found to be markedly degraded by the requirement for multiple channel monitoring, and the problem was not resolved by extensive practice.

In another paper, James F. O'Hanlon (Human Factors Research Inc., Goleta, CA) deterioration in detection performance efficiency during carefully simulated, but prolonged, radar watches. In viewing his findings as

supporting an extension of the arousal hypothesis of vigilance, he noted electrocortical changes involving the percentages of theta, alpha, and beta waves in the spontaneous EEG which were significantly related to target detection performance.

Richard Thackray (FAA Civil Aeromedical Institute, USA) using a simulated air traffic control task, found that groups who rated this task as boring and monotonous differed significantly from those who did not, in that they had greater increases in "long response times," heart rate variability, and strain. Thackray felt that the pattern of responses associated with boredom and monotony was more closely related to attentional processes than to "arousal."

Eimatsu Takakawa (Hokkaido University School of Medicine, Japan) described the development of a unique test procedure for measuring the "mental stress" of various operational tasks having a vigilance component, and showed its sensitivity to different work procedures. Angus Craig (University of Sussex, UK) reported two experiments on the effects on inspection performance of biasing the observer's criteria of importance toward different features of the objects being inspected.

Many of the operationally oriented papers described relationships between various physiological measures and vigilance performance. In addition there were a number of papers whose primary emphasis was on the physiological measures themselves. Anthony Gale (University of Wales, UK) reported two studies of the EEG correlates of sustained attention in which it was shown that the EEG is sensitive to such variables as time, signal ratios, and performance as well as whether the subjects performed alone or in pairs, with friends or strangers, cooperatively or in competition. The sensitivity of EEG waveforms to different task and situational variables was emphasized, and it was concluded that the EEG is at least as good a psychophysiological index of arousal as some of the more popular measures such as heart rate, electrodermal activity, slow potentials, and so forth.

D.R. Davies (University of Aston in Birmingham, UK) discussed the use of the evoked potential (EP) in relation to vigilance performance. He concluded that both late amplitude and latency measures of the EP are significantly related to performance changes within a watch session, to differences in response latency

associated with different response categories, and to the effects of independent variables such as event rate and signal regularity. Nicholas J. Carriero (US Army Human Engineering Laboratory, USA) examined the effectiveness of several physiological measures in relation to correct or incorrect performance in a repetitive visual task and found significant accuracy-by-time interactions for a number of physiological parameters. E. Grandjean (Swiss Federal Institute of Technology) described progressive changes in critical flicker frequency as a function of time spent performing a variety of vigilance tasks and reported significant differences in the CFF and other characteristics of air traffic controllers during heavy-traffic daylight operations versus the less demanding operations during night and early morning hours.

Stuart J. Dimond (University College, Cardiff, UK) reported on the usefulness of vigilance tasks in assessing some of the behavioral consequences of the split-brain condition and expressed the view that there are two different vigilance systems in the two hemispheres of the brain. Studies of split-brain man, he reported, show differences between the performance of the two hemispheres and in addition reveal gross failures of vigilance performance when there is a total-split condition that does not occur with a partial section that preserves the splenium.

A number of papers were given on the effects of various stressors on vigilance performance. Performing a monotonous task may be quite stressful in itself, but these papers had to do with sources of stress other than the main vigilance task. Earl Alluisi (Old Dominion University, USA) reported on the results of a large number of studies involving extended hours of continuous work and various degrees of sleep loss. He compared performance decrements on simulated operational tasks with those on typical vigilance tasks, when the two types of tasks were performed in conjunction with one another, as happens in many real-life operations. He found that the decrements in vigilance performance were no greater, and sometimes even less severe, than were those with the other types of operational tasks. Alluisi felt that this seriously questioned the findings of many laboratory studies in which only single-task watchkeeping tests have been employed.

Jackson Beatty (University of California at Los Angeles, USA) reported an interesting study of the effects of sleep deprivation on the monitoring performance of

anestheologists during simulated surgery. Their performance was shown to be significantly degraded by amounts of sleep loss typically experienced during round-the-clock hospital operations, although no differences were observed in monitoring efficiency for short periods under alerted conditions.

J.L. Bassano (Centre d'Etudes et de Recherches de Psychologie Appliquée, France) reported a very extensive, 30-day study in which conventional Navy watch schedules, with progressive 4-hour time-shifting of the watches, were contrasted with conventional work/rest cycles that more closely related to man's natural 24-hour bio-rhythms. He concluded that the latter schedules were far more effective for maintaining vigilant performance than the ones typically employed in the Navy.

Anders Kjellberg (University of Uppsala, Sweden) provided a theoretical framework within which the performance effects of sleep deprivation might be interpreted. An interactional view of the relationship between sleep deprivation is to potentiate the dearousing effect of situational variables.

In a study of automobile driving, Robert Mackie showed that driver alertness, as reflected by vehicle control and a number of physiological parameters, deteriorates significantly more under heat stress of the type experienced in many parts of the world during the summer months, than it does as a simple function of drive time alone.

Finally, E.C. Poulton (MRC Applied Psychology Unit, UK) emphasized the complex relationships between stressors and vigilance, and reported data supporting the view that a number of stressors, including mild heat, continuous noise, vertical vibration at certain frequencies, and perceptual isolation can act, under proper circumstances, to increase vigilance rather than lower it.

A number of investigators emphasized the importance of interactions between various personality variables and vigilance task performance. Robert Kennedy (US Navy Pacific Missile Test Center) suggested the probable importance of these kinds of interactions in his work on vigilance and vestibular habituation. He felt that individuals differ greatly in their ability to handle vigilance tasks of different complexity, as defined by the number of channels that must be monitored simultaneously. Carl Stroh (Government of Newfoundland and Labrador, Canada),

in relating various physiologic measures to whether or not a particular signal was detected, found no significant relationships until he took into account individual differences in the subjects' neuroticism and age. He noted that older, less neurotic subjects improved their performance when their arousal level was raised, but younger, more neurotic individuals showed a performance decrement with increased arousal. Roger Ware (Indiana University - Purdue University at Indianapolis, USA) also focused on the importance of personality, motivational, and individual difference variables and emphasized the lack of systematic research on the influence of such variables as mental set, suggestion, and levels of consciousness.

R. Parasuraman (University of Aston in Birmingham, UK) presented a taxonomy of vigilance tasks which emphasized individual differences in such traits as perceptual speed and flexibility of closure. He showed that these ability categories exert a significant influence on the apparent consistency of performance between different vigilance tasks, and that individual differences in vigilance performance are not so much task-specific, as some investigators have reported, as task-type specific. He showed how the vigilance task taxonomy provided a systematic framework for the research literature such that improved generalizations could be made in extrapolating data from one laboratory task to another and from laboratory to operational tasks.

A final session was devoted to theoretical considerations. F. Nachreiner (University of Dortmund, FRG) questioned the relevance and applicability of laboratory vigilance research to the problems of monitoring and inspection behavior in field situations in view of the differential motivation that often exists between laboratory and real world environments, and presented empirical data to support his view.

Joel Warm (University of Cincinatti, USA) analyzed vigilance tasks within the framework of several task relevant stages: (1) storage of background information, (2) selection of stimulation and the operation of sensory transducers, (3) orientation movements and decision-making and (4) activity of neural attention units. It was suggested that various theoretical models have focused upon somewhat different aspects of these different stages and most of them can account for some but not all of the data. Each theoretical model was critized on several grounds.

Michael Loeb (University of Louisville, USA) reviewed

the effects of numerous display, task, and organismic variables known to influence monitoring behavior and assessed the principal models or theories used to explain such behaviors in light of the empirical findings. In summarizing the current status of vigil nce theories, he indicated that recent research, like previous research, has failed to confirm any one theory exclusively; the data available continue to cast doubt on the prospect of any current theories being able to account adequately for all established vigilance phenomena; the differentiation of "cortical arousal" may provide a basis for a useful advance in an arousal theory explanation of some monitoring phenomena, especially as related to certain brain wave activities; and, finally, other factors not encompassed by any of the theories are known to affect vigilance behavior, some of them to appreciable extents.

John Swets (Bolt, Beranek and Newman, Inc., USA) reviewed the application of signal detection theory to vigilance, particularly with respect to work reported during the past 6 years. He reported several studies showing that the subject's decision criterion varied appropriately with changes in signal probability, but some showing that it varies less reliably with changes in the payoff matrix. The shift in the decision criterion with time, observed in most earlier studies, was again a common finding, but only a minority of studies found a shift in sensitivity. An evaluative review was given by Swets of the often-conflicting discussions by various authors of the role that signal detection theory can and should play in the study of vigilance.

Illustrating the usefulness of signal detection theory, Douglas Vickers (University of Adelaide, Australia) and D.W.J. Corcoran (University of Glasgow, UK) presented papers directed at assessing changes in the subjects' criterion level (B) and sensitivity (d') as a function of manipulations in various signal parameters. Corcoran showed the interesting result that increases in sound pressure level of signals presented to the ear can affect both d' and B even though physical S/N ratio is not changed, and that an increase in amplitude midway through the task can actually produce a "vigilance increment." Vickers reported a study, using visual signals, in which a progressively declining signal probability throughout the watch produced an increase in the probability of correctly reporting a signal as a function of the length of the session, that is, a significant decrease in B. To account for this unusual result he proposed an adaptive model relating B to a priori signal probability.